UNIVERSITY OF MINNESOTA
MINNESOTA GEOLOGICAL SURVEY
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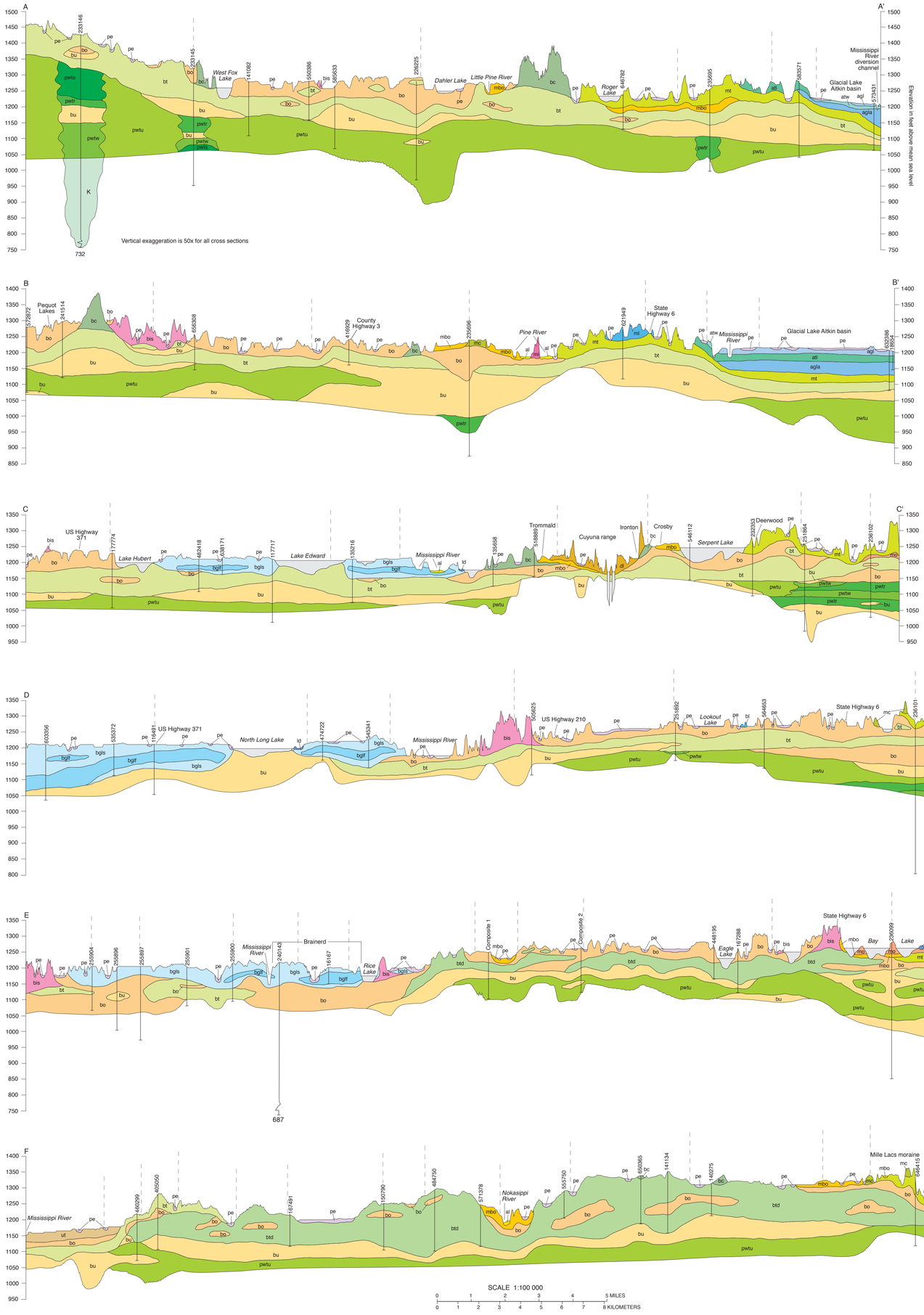
COUNTY ATLAS SERIES
ATLAS C-16, PART A
Plate 4—Quaternary Stratigraphy



DESCRIPTION OF MAP UNITS

GEOLOGIC UNITS FROM PLATE 3, *SURFICIAL GEOLOGY* — See Plate 3 for complete descriptions of geologic units.

HOLOCENE AND LATE PLEISTOCENE

- **dl** — **Disturbed land**
- **pe** — **Peat and other organic sediments**
- **al** — **Floodplain alluvium**
- **ld** — **Lacustrine sediments**

Late Wisconsinan deposits

- **ut** — **Upper terrace sediments**

PLEISTOCENE

Deposits of the St. Louis sublobe—Aitkin assemblage

- **agl** — **Glacial Lake Aitkin II deposits**
- **atw** — **Nelson Lake wave-washed till deposits**
- **atl** — **Nelson Lake till deposits**

Deposits of the Superior lobe—Mille Lacs deposits of the Cromwell Formation

- **ml** — **Lake sand and silt**
- **mo** — **Outwash**
- **mbo** — **Mixed outwash**
- **mi** — **Ice-contact stratified materials**
- **mc** — **Till, sand, and gravel complex**
- **mt** — **Garrison till deposits**

Deposits of the Rainy lobe—Brainerd assemblage

- **bl** — **Lake sand and silt**
- **bo** — **Outwash**
- **bis** — **Ice-contact stratified materials**
- **bc** — **Till, sand, and gravel complex**
- **bt** — **South Long Lake till deposits**
- **btd** — **South Long Lake drumlinized till deposits**

UNITS MODIFIED FROM PLATE 3

PLEISTOCENE

Deposits of the Rainy lobe—Brainerd assemblage

- **bgls** — **Sandy Glacial Lake Brainerd deposits**—Well-sorted, very fine- to medium-grained, noncalcareous sand. In places sediment may contain minor interbedded silt and clay layers. This is the coarse-grained component of map unit bgl from Plate 3. Eolian sand (see Plate 3) in places covers the lake sediment, sometimes forming dunes (Hobbs, 2001a, 2001b; Knaeble, 2001). The eolian sand is difficult to distinguish from the lacustrine deposits, as both are composed of well-sorted, very fine- to medium-grained sand; therefore, because its thickness is highly speculative, the eolian sand is included in this unit and is not shown on the cross sections.
- **bglf** — **Fine-grained Glacial Lake Brainerd deposits**—Commonly composed of interbedded layers of silt and clay with some very fine-grained sand layers. In places laminations are interpreted to be varves (annual cycles of sedimentation: winter–clay/summer–silt). Massive silt beds are common in places. This is the fine-grained component of map unit bgl from Plate 3.

Pre-Late Wisconsinan deposits

- **pwtw** — **Till**—Dense, silt loam- to loam-textured, unsorted sediment that contains pebbles, cobbles, and boulders. Carbonate pebbles are common to abundant. Trace amounts of gray shale may be present. Interpreted to have been deposited by Winnipeg-provenance (Fig. 2) ice that advanced into Minnesota from the northwest.
- **pwtr** — **Till**—Dense, sandy loam- to loam-textured, unsorted sediment that contains pebbles, cobbles, and boulders. Carbonate is rare to uncommon. Gray shale is absent. Interpreted to have been deposited by Rainy-provenance ice that advanced into Minnesota from the northeast.
- **pwts** — **Till**—Dense, reddish colored, unsorted sediment that contains pebbles, cobbles, and boulders. Carbonate is rare to absent. Gray shale is absent. Red felsite is common. Interpreted to have been deposited by Superior-provenance ice that advanced from the northeast through the Superior basin into Minnesota.
- **pwtu** — **Till**—Dense, sandy loam- to clay loam-textured, unsorted sediment that contains pebbles, cobbles, and boulders. Includes lenses and layers of fluvial sand and gravel, and lacustrine sand, silt, and clay. This material is equivalent to that found in units pwtw, pwtr, and pwts but signifies undifferentiated till in the cross section because insufficient data were available to determine the provenance of the till.

UNITS ON THE CROSS SECTIONS ONLY

HOLOCENE

- **Water**—Present-day lake basins.

PLEISTOCENE

- **agla** — **Glacial Lake Aitkin I deposits**—Silt and clay; chiefly massive beds with layering and laminations in places; a few sand layers. Commonly gray with some red layers and streaks. Contact with the overlying St. Louis sublobe till deposits is gradational.

Pre-Late Wisconsinan and Rainy lobe deposits

- **bu** — **Bedded sediment**—Chiefly sand and gravel deposits from glacial outwash streams of pre-Late Wisconsinan ice advances; includes sand, silt, and clay lake deposits of all ages; may contain stream alluvium deposited during interglacial episodes; may also include meltwater sediment of the Rainy lobe where in contact with Rainy lobe units. This unit might include local till lenses and layers particularly where the unit is thick or where data are scarce.

MESOZOIC

Cretaceous bedrock deposits—Coleraine Formation

- **K** — **Cretaceous deposits**—Red, pink, white, gray, green, brown, and purple interbedded sandstone, siltstone, and claystone. The bottom 25 feet (8 meters) may be weathered Pre-Cambrian bedrock (saprolith).

CROSS SECTION SYMBOLS

- Geologic contact
- Drill hole
- Bend in section

LOCATION OF QUATERNARY CROSS SECTIONS

LOCATION DIAGRAM

QUATERNARY STRATIGRAPHY

By

Alan R. Knaeble and Gary N. Meyer

2004

INTRODUCTION

The Quaternary stratigraphy of Crow Wing County shows the unconsolidated materials expected to be encountered between the land surface and bedrock. Outcrops, drill cuttings, auger samples, water-well drillers' logs, and drill core were used to interpret the stratigraphy. The geologic units depicted on the Quaternary cross sections were defined using previous studies completed in the area and through the interpretation of new data collected for this study. The unit descriptions match those on Plate 3, *Surficial Geology*, except for units that have been modified or that only appear on the cross sections. Stratigraphic control points are indicated by drill hole symbols and the associated unique number. Many other drill hole logs were used to interpret the cross section stratigraphy, but they are not shown due to space limitations. A few rotary-sonic drill core and water-well drillers' cuttings samples collected from sites outside the county were used in the interpretation because they were near the county border and provided significant detailed stratigraphic control. These drill sites are not shown on the cross sections but their unique well numbers are included in the digital file data. The tops of the drill hole symbols shown on the cross sections may not exactly coincide with the cross section surface elevation line. This is because these drill holes are located near (commonly within 1 mile [1.6 kilometers]) but not exactly on the cross section line and therefore have a different surface elevation. On cross section E–E' the labels Composite 1 and Composite 2 are assigned to respective drill hole symbols. The stratigraphic interpretation of the Quaternary materials at each of these two sites is based on a group of subsurface drill holes to the bedrock surface located near the cross section line. These data were gleaned from exploratory drill holes from Adams' exploration data archived at the Minnesota Geological Survey. Vertical exaggeration is 50 for all cross sections. Elevation values are given in feet above mean sea level.

The topographic expression created by glacial sculpturing and subsequent meltwater sediment deposition is displayed on the Digital Elevation Model (Fig. 1). Figure 2 shows the major provenances—the source areas of materials transported by the ice lobes. Figure 3 combines age, unit stratigraphic position, and location to schematically illustrate the relationships between the sediments deposited by major glacial episodes. A simplified view of cross section E–E' at a reduced scale is shown in Figure 4 as an example of the correlation between the cross sections and units on the Quaternary Subsurface Geology map (Plate 5). Analysis of the texture and rock types of the Quaternary sediments was done for selected geologic units, as listed in Table 1, as an aid to understanding the characteristics of each. In this table the analyzed sample values listed under the lithology heading and crystalline-carbonate-shale category for the St. Louis sublobe till deposits (Nelson Lake till) and Superior lobe till deposits (Garrison till) represent unleached samples only (carbonate rock fragments are not dissolved, so the sample is still calcareous). Sample values of the Rainy lobe till deposits (South Long Lake till) represent both leached (140 samples) and unleached (24 samples) till. The Rainy lobe till deposits are commonly leached to a depth of greater than 15 feet (5 meters) because of the lobe's sandy texture and its original low carbonate content (the 24 unleached samples that were collected from drill core and auger holes average about 3 to 4 percent carbonate for the 1-2 millimeter grain size).

ACKNOWLEDGEMENTS

Brian Ross and Mark Erickson of Widseth, Smith, and Nolting provided cuttings samples and detailed geologic logs of nine bedrock drill holes in the Baxter area. Howard Mooers, professor of Geology at the University of Minnesota Duluth, arranged for us to collect drilling samples and describe rotary-sonic core from drill holes on the Camp Ripley National Guard Training Facility west of the county. Al Dzuck of the Minnesota Department of Natural Resources arranged for us to sample and describe rotary-sonic core (drilled by the Minnesota Department of Natural Resources) stored in the Hibbing core storage facility. We thank Dr. Allan Schneider, retired professor of the University of Wisconsin-Parkside, who supplied samples, field descriptions, test data, and insight from work he did in the area during the 1950s.

REFERENCES

Hobbs, H.C., 1998, Use of 1-2 millimeter sand-grain composition in Minnesota Quaternary studies, *in* Patterson, C.J., and Wright, H.E., Jr., eds., Contributions to Quaternary studies in Minnesota: Minnesota Geological Survey Report of Investigations 49, p. 193-208.

———2001a, Surficial geology of the Brainerd quadrangle, Crow Wing County, Minnesota: Minnesota Geological Survey Miscellaneous Map M-112, scale 1:24,000.

———2001b, Surficial geology of the Gull Lake quadrangle, Cass and Crow Wing Counties, Minnesota: Minnesota Geological Survey Miscellaneous Map M-113, scale 1:24,000.

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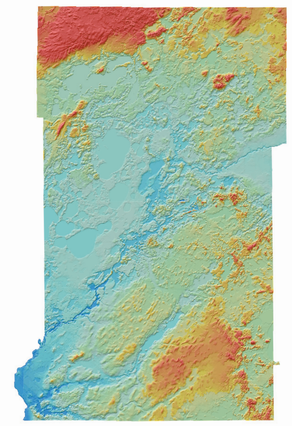

Figure 1. Physical relief of the land surface in Crow Wing County. Scale is 1: 500,000. Elevation is shown by color: red (higher surface elevation) grading to blue (lower surface elevation). A false sun illumination, at an elevation of 30 degrees, from the northwest (315°) provides contrast (gray shadowing) to accent details of landforms. The map was created using the U.S. Geological Survey's Digital Elevation Model with a 30 meter grid.

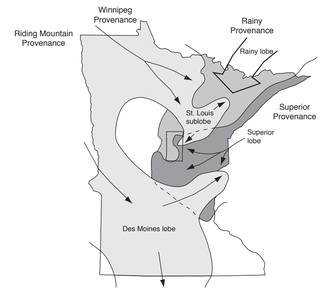

Figure 2. Location of major provenances. Glacial sediments deposited in the county derive their distinct material content from bedrock found in the region of these provenances. During the last glaciation, the Late Wisconsinan, Crow Wing County was completely covered by ice of the Rainy lobe, which moved into the county from the northeast. Following the retreat of the Rainy lobe, the Superior lobe moved into the county from the east (the line of maximum extent of the Superior lobe is dashed where buried by later advances). Lastly, ice originating northwest of Crow Wing County formed the St. Louis sublobe, which also flowed into the county from the east.

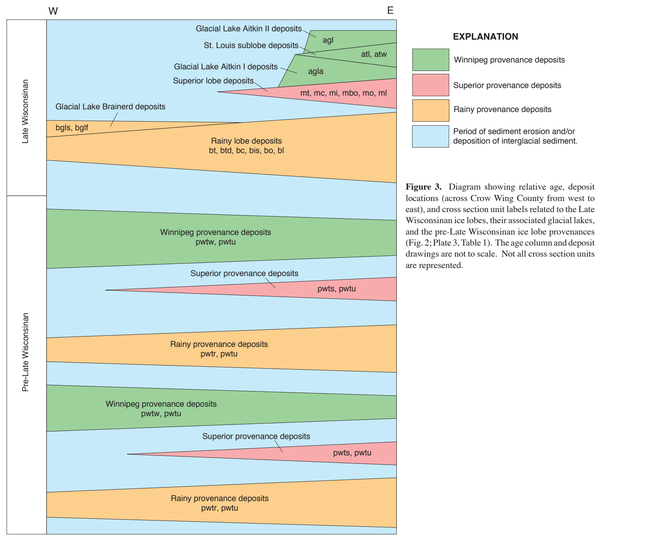

Figure 3. Diagram showing relative age, deposit locations (across Crow Wing County from west to east), and cross section unit labels related to the Late Wisconsinan ice lobes, their associated glacial lakes, and the pre-Late Wisconsinan ice lobe provenances (Fig. 2; Plate 3, Table 1). The age column and deposit drawings are not to scale. Not all cross section units are represented.

Table 1. Average values for the matrix texture and composition of tills, glacial lake sediments, and outwash sediments recognized in Crow Wing County. Matrix texture is expressed as relative proportions of sand, silt, and clay in percent. The composition of the very coarse-grained sand (1-2 millimeters) fraction is expressed as relative proportions of crystalline, carbonate, and shale rock types in percent. The crystalline samples were further differentiated by crystalline rock type—light (granite and gneiss), dark (mafic-igneous and other metamorphic rocks), and red (iron-formation, rhyolite, agate, and sandstone; Hobbs, 1998). See the geologic unit descriptions of the cross section for a brief explanation; complete descriptions of surficial units are given on Plate 3.

	MATRIX TEXTURE			*LITHOLOGY (ROCK TYPE)*		
Deposit description and geologic units shown on cross sections and Plate 3	Total number of samples	**Gravel**—Percentage of total sample weight	**Sand-silt-clay** Percentage in 1-2 mm fraction	Total number of samples	**Crystalline-carbonate-shale** Percentage of total grains counted	**Light-dark-red** Percentage of total crystalline grains counted
Deposits of the St. Louis sublobe (Aitkin assemblage)						
Silt and clay of Glacial Lake Aitkin II (agl)	3	1	16-36-48	3	93-7-0	86-10-4
Nelson Lake till (atw, atl)	80	2	24-39-37	70	93-7-0	84-14-2
Silt and clay of Glacial Lake Aitkin I (agla)	31	0	7-44-39	15	96-4-0	83-14-3
Deposits of the Superior lobe (Mille Lacs deposits of the Cromwell Formation)						
Garrison till (mt, mc)	184	6	37-43-20	127	99-1-0	56-30-14
Sand and gravel outwash (mo)	5	16	81-15-4	11	99-1-0	65-24-11
Deposits of the Rainy lobe (Brainerd assemblage)						
Sand of Glacial Lake Brainerd (bgls)	31	0	91-6-3	28	100-0-0	80-14-6
Silt and clay of Glacial Lake Brainerd (bglf)	28	0	27-52-21	26	100-0-0	77-17-6
South Long Lake till (btd, bt, bc)	194	9	67-22-11	164	100-0-0	78-15-7
Sand and gravel outwash (bo)	56	13	92-5-3	57	100-0-0	79-15-6

Figure 4. Simplified view of cross section E–E' with the tills and fine-grained lacustrine sediments (silt and clay) shown in shades of green as confining units, and the sand and gravel sediment shown in shades of brown as aquifers. The color bar above the simplified cross section links the cross section with the Quaternary Subsurface Geology map on Plate 5 (where the location of cross section E–E' is also shown). Subsurface map units displayed on the color bar correspond to the number and relative position of aquifers and confining units in the subsurface on the simplified cross section. Scale is 1:200,000.

GEOLOGIC ATLAS OF CROW WING COUNTY, MINNESOTA

Cross section compilation by R.S. Lively
Edited by Lori Robinson